Implementation of a Semantic Network Product Using a Standard Database Platform

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As part of an open decision support architecture, we have developed an application-readable medical reference tool. The Medical Concepts Dictionary (MCD) contains knowledge about health care delivery, complementing patient-specific knowledge held in a separate clinical data repository product.

The MCD serves two purposes. First, the MCD can map synonyms both between clinical data repositories and departmental systems providing data (laboratory, ADT, radiology, etc.), and between concepts internal to the MCD. Second, the MCD can represent the complex network of relationships among medical concepts. Together, these features enable decision support applications to query clinical data repositories at multiple levels of granularity and to make inferences.

Support for synonymy, hierarchy, and other complex relationship mapping has proven essential to clinical decision support systems. For example, it is useful to be able to ask for the properties of a drug, to ask if the patient has had thoracic surgery, or to identify all patients with any kind of pneumonia. Decision support applications need to make such queries efficiently at run time, and developers need to be able to visualize such relationships clearly during development of applications for cost control, alerting, trending, order critiquing, organizational modeling, clinical protocols, and monitoring adherence to policies & procedures.

Close integration of the MCD with other applications was a principle design requirement. The MCD also had to be architecturally simple, open and extensible, and provide near real time performance without sacrificing necessary powerful expressive capabilities. In addition, the MCD had to be intuitive enough for clinical users to augment while retaining compatibility with state of the art controlled medical vocabularies.

The MCD design is based on a semantic network model (a technique used by others in related research [1]), and was implemented using a standard relational database management system. A semantic network is a graph design in which nodes (concepts) are connected using labeled arcs (relationship types). Each connection between two concepts forms an instantiated graph (relationship). MCD concepts are identified using naming words (e.g., acetaminophen, analgesic, surgery, Intensive Care Unit, femur, etc.). MCD relationship types link ordered pairs of concepts (e.g., "is_a", "has_property"). Fundamental MCD relationship types are provided by the UMLS® [2] Semantic Relations. MCD relationships are instantiated relationship types, e.g., the relationship "appendectomy is_a surgical procedure" is instantiated using the concepts "appendectomy" and "surgical procedure" and the relationship type "is_a". The MCD design minimizes the number of joins required for queries and the number of tables with which the knowledge base developer must become familiar. Multiple inheritance and hierarchies of unlimited depth are supported.

Tools for loading, editing, checking consistency, enhancing run-time performance, and integrating other applications with the MCD have been developed. Because the potentially enormous content of the MCD is unlikely to be developed by a single source, we have also developed tools for incorporating other compatible terminologies.

We believe the simple MCD elements reduce the complexity of queries and content development while retaining the expressive capability needed for clinical decision support. The MCD is currently in transition from research and development to commercial implementation.

References

[1] Cimino JJ, Hripsak G, Johnson SB, Clayton PD. Designing an introspective, multipurpose, controlled medical vocabulary. In Kingsland L, Ed., Proceedings, 13th SCAMC. Washington, D.C.: IEEE Computer Society Press, 1989:513-8

[2] UMLS Knowledge Sources, 5th Experimental Edition, U.S. Department of Health and Human Services, National Institutes of Health, National Library of Medicine, 1994